

**NEW UTILITY PATENT APPLICATION  
TRANSMITTAL***(Only for new nonprovisional applications under 37 C.F.R. 1.53(b))*Docket No.  
M4065.165/P165Total pages in this  
submission**TO THE ASSISTANT COMMISSIONER FOR PATENTS****Box Patent Application  
Washington, D.C. 20231**

Transmitted herewith for filing under 35 U.S.C. 111(a) and 37 C.F.R. 1.53(b) is a new utility patent application for an invention entitled:

**METHOD FOR ETCHING DOPED POLYSILICON WITH HIGH SELECTIVITY TO UNDOPED POLYSILICON**

and invented by:

Garry Mercaldi and Donald Yates

If a **CONTINUATION APPLICATION**, check appropriate box and supply requisite information:☐

Continuation

☐

Divisional

☐

Continuation-in-part (CIP) of prior application No.: \_\_\_\_\_

Enclosed are:

**Application Elements**

1. ☒ Filing fee as calculated and transmitted as described below
2. ☒ Specification having 23 pages(s) and including the following:
  - a. ☒ Descriptive title of the invention
  - b. ☐ Cross references to related applications *(if applicable)*
  - c. ☐ Statement regarding Federally-sponsored research/development *(if applicable)*
  - d. ☐ Reference to microfiche appendix *(if applicable)*
  - e. ☒ Background of the invention
  - f. ☒ Brief summary of the invention
  - g. ☒ Brief description of the drawings *(if drawings filed)*
  - h. ☒ Detailed description
  - i. ☒ Claims as classified below
  - j. ☒ Abstract of the disclosure

**Application Elements (continued)**

3. ☒ Drawing(s) (when necessary as prescribed by 35 U.S.C. 113)  
☐ Formal ☒ Informal Number of sheets: 3
4. ☒ Oath or Declaration  
a. ☒ Newly executed (original or copy) ☐ Unexecuted  
b. ☐ Copy from a prior application (37 C.F.R. 1.63(d) (for continuation/divisional applications only))  
c. ☐ With Power of Attorney ☒ Without Power of Attorney
5. ☐ Incorporation by reference (usable if Box 4b is checked)  
The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.
6. ☐ Computer program in microfiche
7. ☐ Genetic sequence submission (if applicable, all must be included)  
a. ☐ Paper copy  
b. ☐ Computer readable copy  
c. ☐ Statement verifying identical paper and computer readable copies

**Accompanying Application**

8. ☒ Assignment papers (cover sheet & document(s))
9. ☒ 37 C.F.R. 3.73(b) statement (when there is an assignee)
10. ☐ English translation document (if applicable)
11. ☒ Information Disclosure Statement/PTO-1449 ☒ Copies of IDS citations
12. ☐ Preliminary Amendment
13. ☒ Acknowledgment postcard
14. ☐ Certified copy of priority document(s) (if foreign priority is claimed)
15. ☐ Certificate of Mailing  
☐ First Class ☐ Express Mail (Label No.: \_\_\_\_\_ )
16. ☐ Small Entity statement(s) -- # submitted \_\_\_\_\_ (if Small Entity status claimed)

**Accompanying Application (continued)**

- 17.
- ☐
- Additional enclosures (please identify below):

**Fee Calculation and Transmittal**

The filing fee for this utility patent application is calculated and transmitted as follows:

☒ Large Entity ☐ Small Entity

CLAIMS AS FILED					
For	# Filed	# Allowed	# Extra	Rate	Fee
Total Claims	81	- 20 =	61	x \$18.00	\$1,098.00
Independent Claims	5	- 3 =	2	x \$78.00	\$156.00
Multiple Dependent Claims (check if applicable) <input type="checkbox"/>					
Other Fees (specify purpose):					
BASIC FEE					\$760.00
TOTAL FILING FEE					\$2,014.00

☒ A check in the amount of \$2,014.00 to cover the total filing fee is enclosed.☒ The Commissioner is hereby authorized to charge and Deposit Account No. 04-1073 as described below. A duplicate copy of this sheet is enclosed.☐ Charge the amount of \_\_\_\_\_ as filing fee.☒ Credit any overpayment.☒ Charge any additional filing fees required under 37 C.F.R. 1.16 and 1.17.☐ Charge the issue fee set in 37 C.F.R. 1.18 at the mailing of the Notice of Allowance, pursuant to 37 C.F.R. 1.31(b).Dated: April 5, 1999

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Docket No.: M4065.165/P165  
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE  
APPLICATION FOR U.S. LETTERS PATENT

Title:

**METHOD FOR ETCHING DOPED POLYSILICON WITH HIGH  
SELECTIVITY TO UNDOPED POLYSILICON**

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## **METHOD FOR ETCHING DOPED POLYSILICON WITH HIGH SELECTIVITY TO UNDOPED POLYSILICON**

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### **Field of the Invention**

The present invention relates to the field of chemical etching and, in particular, to wet chemical etching of substrates, such as a silicon semiconductor structures, with improved selectivity. The process is particularly adapted for use in producing improved pattern definition in the etching of silicon structures.

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### **Background of the Invention**

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As the demand for ever-smaller silicon devices continues, and as resolution continues below the sub-micron level, the need for uniform and precise micromachining is increasing. The manufacture of semiconductor integrated circuits typically involves highly complex, time consuming and costly processes which, with continually narrower line width requirements, must be achieved with an ever increasing degree of precision. Within such processes the etching of semiconductor material (e.g., silicon) often entails the use of a chemical bath to which a patterned semiconductor material is exposed, so as to etch selectively certain portions of the surface of a wafer. In a typical chemical etch process, both the rate of etch and the selectivity of etch are parameters critical to the successful formation of an intended substrate geometry.

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When the etchant is applied to the semiconductor material (e.g., silicon), the amount of etching performed is dependent upon the etch rate, the length of time the etchant is applied and other physical factors. The direction of the etch is determined by the degree to which the selected etching process is isotropic or anisotropic. Etching which proceeds in all directions at the same rate is said to be "isotropic." By definition, any etching that is not isotropic is anisotropic. The etching of structures from polysilicon requires a process having a high degree of selectivity and anisotropy, without damaging the structure being formed. The problem is exacerbated by the requirements of sub-micron geometries. Wet etching, for example, is isotropic. Many etching processes typically fall between the extremes of being isotropic and completely anisotropic and, therefore, some unwanted etching is common even under the best conditions of prior etching processes.

Another solution is to make an isotropic etchant "selective." An etching process may be made "selective" to one surface over another based upon a variety of characteristics of the material being etched. These characteristics are termed "etch rate varying characteristics" and include, but are not limited to, chemical composition, the ratio of the etchant components, dopant levels, density, post-deposition annealing conditions, deposition temperature and deposition pressure. By making an etching process or etchant "selective" to a particular surface or composition, the process or etchant will etch that particular surface or composition less rapidly than the surrounding surface or other material with which the etchant may come into contact. Accordingly, when an etchant is

selective for a heavily doped material such as heavily boron doped BPSG, the etchant will etch layers of material containing heavily boron doped BPSG less quickly than other layers not similarly composed.

Various etching techniques and compositions have been used in the fabrication of semiconductor integrated circuits. For example, U.S. Pat. No. 3,677,848 (Irwin et al.) describes an etching method which immerses a semiconductor body into a mixture of hydrofluoric acid, nitric acid, acetic acid and either sodium chlorite or sodium nitrite. The patent describes that the mixture will etch a silicon or germanium body at a rate of 0.00033 to 0.001 inch/minute. However, the mixture does not have any selectivity to different parts of the silicon or germanium body.

U.S. Pat. No. 4,026,733 (Owen, III et al.) describes a process for defining polycrystalline silicon patterns from a masking member. The patent describes that self-limiting etching of the silicon is achieved through an etchant that discriminates between doped and undoped silicon. The selective etchant solution of the '733 patent includes hydrofluoric acid, nitric acid and acetic acid.

U.S. Pat. No. 4,142,926 (Morgan) describes a process for fabricating a double layer polycrystalline silicon structure for a metal-oxide-semiconductor (MOS) integrated circuit by employing a selective etchant which discriminates between silicon layers. The '926 patent recites that the selective etching solution includes hydrofluoric acid, nitric acid and acetic acid and selectively etches phosphorous doped polycrystalline silicon.

U.S. Pat. No. 4,681,657 (Hwang et al.) describes an etchant composition and method for resistivity specific etching of doped silicon films which overlie intrinsic or lightly doped crystal regions. The etching method includes contacting a semiconductor body with a mixture of hydrofluoric acid, nitric acid and predominantly acetic acid/water mixture.

U.S. Pat. No. 5,532,182 (Woo) describes a process for fabricating stacked DRAM capacitors. The patent describes an etching solution including nitric acid, acetic acid, hydrofluoric acid and deionized water in a ratio of from 30:3:0.5:15 to 30:3:1:15.5 to selectively etched doped silicon.

U.S. Pat. No. 5,637,523 (Fazan et al.) describes a method of forming a capacitor. The patent recites that an etching solution including 0.7% of hydrofluoric acid, 50 to 54% nitric acid and 2.6% acetic acid selectively etched doped polycrystalline silicon. Additionally, the patent describes a selective etching solution including 0.53% HF, 37.63% HNO<sub>3</sub>, 22.58% CH<sub>3</sub>COOH and 4.21% NH<sub>4</sub>F with the remainder deionized water achieved a selectivity of greater than 3:1 undoped to doped silicon.

As discussed above, these proposed solutions and additional proposed solutions have been attempted to selectively etch semiconductor materials in the manufacture of integrated circuits with high selectivity. These additional attempts include using anisotropic etchants, tailoring the chemical concentrations of known isotropic etching solutions, and tailoring the physical environments of

etching apparatus. However, these prior methods have not provided an etching composition and method having a high selectivity.

### **Summary of the Invention**

5           The present invention has advantages over the previous methods in that selectivity of the etching of doped polysilicon is increased with respect to undoped polysilicon. The present invention provides an etching mixture including a polyhydric or lower alkyl alcohol together with a combination of two or more acids. Preferably the etching composition of the present invention is a  
10           mixture of a glycol, nitric acid and hydrofluoric acid, with propylene glycol being preferred. By providing an etching formulation which has increased selectivity of doped polysilicon to undoped polysilicon, the present invention provides an efficient integrated circuit fabrication process without requiring time consuming and costly processing modifications to the etching apparatus or production  
15           apparatus.

### **Brief Description of the Drawings**

Fig. 1 is a diagrammatic cross-sectional view of a portion of a semiconductor wafer at an intermediate processing step.

20           Fig. 2 is a diagrammatic cross-sectional view of a portion of a semiconductor wafer at a processing step subsequent to that shown in Fig. 1.

Fig. 3 is a scanning electron microscope (SEM) photograph of a silicon substrate processed according to the present invention.

Fig. 4 is a SEM photograph of a silicon substrate processed according to the present invention.

### **Detailed Description of the Preferred Embodiments**

In the following detailed description, reference is made to the accompanying drawings which form a part hereof, and in which is shown by way of illustration specific embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized, and that structural, logical and electrical changes may be made without departing from the spirit and scope of the present invention.

The terms “wafer” and “substrate” are to be understood as including silicon-on-insulator (SOI) or silicon-on-sapphire (SOS) technology, doped and undoped semiconductors, epitaxial layers of silicon supported by a base semiconductor foundation, and other semiconductor structures. Furthermore, when reference is made to a “wafer” or “substrate” in the following description, previous process steps may have been utilized to form regions or junctions in the

base semiconductor structure or foundation. In addition, the semiconductor need not be silicon-based, but could be based on silicon-germanium, germanium, or gallium arsenide.

The selective etching composition according to the present invention includes an alcoholic component and an acidic component. The selective etching composition optimally includes a polyhydric alcohol or C<sub>2</sub>-C<sub>6</sub> alcohol together with a combination of two or more acids. The selective etching composition of the present invention preferably includes a predominant amount of the alcohol and is also preferably formulated to be a non-aqueous composition, that is a non-water based composition.

The polyhydric alcohols useful in the present invention include any known polyhydric alcohols such as glycerol (also known as glycerin), polyalkylene glycols, and more preferably alkylene polyols and their derivatives, including ethylene glycol, propylene glycol, butylene glycol, dipropylene glycol, polypropylene glycol, polyethylene glycol and derivatives thereof, sorbitol, hydroxypropyl sorbitol, hexylene glycol, 1,3-dibutylene glycol, 1,2,6-hexanetriol, 1,5-pentanediol, ethoxylated glycerol, propoxylated glycerol and mixtures thereof. The C<sub>2</sub>-C<sub>6</sub> alcohols useful in the present invention are those such as ethanol, propanol, isopropanol, iso-butanol, n-butanol and the like as well as mixtures thereof. Preferably, the alcoholic component of the selective etching composition is a polyhydric alcohol. A preferred polyhydric alcohol is a glycol, especially those such as ethylene glycol and propylene glycol.

The acidic component of the selective etching composition of the present invention includes two or more inorganic acids. Examples of inorganic acids suitable for the present invention are those such as hydrofluoric acid, nitric acid, phosphoric acid, sulfuric acid, boric acid, carbonic acid, perchloric acid and sulfurous acid. Preferably the acidic component of the selective etching composition includes hydrofluoric acid and nitric acid.

The selective etching composition of the present invention is comprised primarily of the alcoholic component of the composition. In a preferred embodiment of the invention, the ratio of alcohol to nitric acid to hydrofluoric acid ranges from about 10-50:5-40:1, more preferably from about 20-40:10-30:1. In a most preferred embodiment, the selective etching composition according to the present invention is comprised of propylene glycol, nitric acid and hydrofluoric acid in a ratio of about 30:20:1.

The wafers processed according to the present invention were etched by immersing them in a constantly stirred bath of the etchant at a temperature of from about -10°C to about 70°C, preferably at about 35°C. Stirring of the etching solution can be ultrasonic or by means of a magnetic stirrer. Alternatively, a flow-through agitation or a spray-type etcher could be used.

The selective etching composition of the present invention selectively removes doped materials from the substrate to the exclusion of undoped materials. That is, the selective etching composition of the present invention will rapidly etch materials such as BPSG, doped polysilicon, doped monocrystalline

silicon, doped amorphous silicon, doped pseudocrystalline silicon, doped germanium, doped gallium arsenide while not significantly etching undoped materials.

The invention will now be further described with reference to the figures. Reference is now made to Fig. 1. A semiconductor wafer fragment at an intermediate processing step is indicated generally by reference numeral 100. The semiconductor wafer 100 is comprised of a bulk silicon substrate 112 with field isolation oxide regions 114 and doped active area 120 formed therein. A BPSG layer 142 has been deposited on the substrate. A plug 146 of doped polysilicon conductive material has been deposited in plug openings 150. A doped polysilicon conductive layer 152 has been deposited in plug opening 150. An HSG layer 153 has been deposited over the doped polysilicon conductive layer 152 and the portions of the doped polysilicon conductive layer 152 and the HSG layer 153 above the top of the BPSG layer 142 have been removed through CMP. It should be understood, however that the plug 146 and the doped polysilicon conductive layer 152 may also be formed of doped amorphous silicon, monocrystalline silicon and amorphous silicon.

Referring now to Fig. 2, the BPSG layer 142 and the doped polysilicon conductive layer 152 are then etched back around the HSG layer 153 by immersing the wafer 100 in a etching solution which comprises propylene glycol, nitric acid and hydrofluoric acid in a ratio of 30:20:1 for about 45 seconds in a 35°C etching bath. The etchant selectively removed the BPSG layer

142 and the doped polysilicon layer 152 as illustrated in the figure, but did not applicably remove the undoped HSG layer 153.

The invention is further explained with reference to the following example. This invention is not intended to be limited by the particular example described below. A polysilicon wafer including in-situ doped polysilicon which has been annealed, undoped polysilicon, thermal silicon oxide and rich BPSG which had been annealed and densified was placed in a static etching bath at 35°C with a composition of propylene glycol, nitric acid and hydrofluoric acid in a 30:20:1 ratio for a predetermined time. The etching rate of the silicon substrate was measured as shown in Table 1 below.

Material Etched	Etch Rate (Å/min)
Doped Polysilicon	694.00
Undoped Polysilicon	9.52
Thermal Silicon Oxide	49.80
BPSG (annealed and densified)	1410.67

TABLE 1

Based on the etching rates of the propylene glycol, nitric acid, hydrofluoric acid etchant measured above, the selectivity ratio of the etchant was measured as a ratio of etching rates as shown in Table 2 below.

	Doped Polysilicon	Undoped Polysilicon	Thermal Silicon Oxide	BPSG
Doped Polysilicon	-	73:1	14:1	1:2
Undoped Polysilicon	-	-	1:5	1:148
Therman Silicon Oxide	-	-	-	1:28
BPSG	-	-	-	-

TABLE 2

Table 2 shows that the selective etching composition of the present invention achieved a selectivity ratio of greater than 70:1, doped polysilicon to undoped polysilicon, and a selectivity ratio of greater than 140:1, BPSG to undoped polysilicon. These examples show the unexpectedly high selectivity of the composition of the present invention.

Reference is now made to Figures 3-4. These figures show SEM photographs of a silicon wafer in which blanket polysilicon films (030 ISD annealed and 256 undoped) were immersed in a static etching bath at 35°C with a composition of propylene glycol, nitric acid and hydrofluoric acid in a 30:20:1 ratio for a predetermined time. Fig. 3 is a SEM photograph magnified a 8724 times while Fig. 4 is magnified at 30,000 times. As can be seen from these figures, the complete removal of doped polysilicon is evident. All that remains in the undoped polysilicon showing the high selectivity of the composition of the present invention.

The selective etchant composition according to the present invention can be used in any application requiring the removal of a doped polysilicon layer

overlying intrinsic or lightly doped silicon. The intrinsic or lightly doped silicon need not be single crystal silicon, it can be intrinsic or lightly doped polysilicon. The particular composition chosen will be a function of the thickness of the polysilicon to be removed, and will allow a suitable etch rate for process control purposes. The etchant can also be used in applications where the underlying layer is silicon dioxide or silicon nitride or where a silicon dioxide or silicon nitride layer is otherwise exposed to the etchant for limited times.

It should again be noted that although the invention has been described with specific reference to silicon substrates, the invention has broader applicability and may be used in any process where selective etching is required. Similarly, the process described above is but one method of many that could be used. Accordingly, the above description and accompanying drawings are only illustrative of preferred embodiments which can achieve and provide the objects, features and advantages of the present invention. It is not intended that the invention be limited to the embodiments shown and described in detail herein. The invention is only limited by the spirit and scope of the following claims.

What is claimed as new and desired to be protected by Letters Patent of the United States is:

1. A composition for selectively etching a doped substance, said composition consisting essentially of:

an alcohol and at least two inorganic acids.

2. The composition according to claim 1, wherein said alcohol is a polyhydric alcohol.

3. The composition according to claim 2, wherein said polyhydric alcohol is selected from the group consisting of ethylene glycol, propylene glycol, butylene glycol, dipropylene glycol, sorbitol, hexylene glycol, 1,3-dibutylene glycol, 1,2,6,-hexanetriol and 1,5-pentanediol.

4. The composition according to claim 2, wherein said polyhydric alcohol is selected from the group consisting of ethylene glycol, propylene glycol.

5. The composition according to claim 1, wherein said alcohol is propylene glycol.

6. The composition according to claim 1, wherein said alcohol is a C<sub>2</sub>-C<sub>6</sub> alcohol.

7. The composition according to claim 6, wherein said C<sub>2</sub>-C<sub>6</sub> alcohol is selected from the group consisting of ethanol, propanol, isopropanol, iso-butanol and n-butanol.

8. The composition according to claim 7, wherein said alcohol is isopropanol.

9. The composition according to claim 1, wherein said inorganic acids are selected from the group consisting of hydrofluoric acid, nitric acid, phosphoric acid, sulfuric acid, boric acid, carbonic acid, perchloric acid and sulfurous acid.

10. The composition according to claim 1, wherein said first inorganic acids is nitric acid and said second inorganic acid hydrofluoric acid.

11. The composition according to claim 10, wherein said alcohol is propylene glycol.

12. The composition according to claim 11, wherein said composition is a non-aqueous composition.

13. The composition according to claim 1, wherein the ratio of alcohol to a first acid to a second acid is from about 10-50:5-40:1.

14. The composition according to claim 13, wherein the ratio of alcohol to said first acid to said second acid is from about 20-40:10-30:1.

15. The composition according to claim 14, wherein the ratio of alcohol to said first acid to said second acid is about 30:20:1.

16. The composition according to claim 11, wherein the ratio of propylene glycol to nitric acid to hydrofluoric acid is from about 10-50:5-40:1.

17. The composition according to claim 11, wherein the ratio of propylene glycol to nitric acid to hydrofluoric acid is from about 20-40:10-30:1.

18. The composition according to claim 11, wherein the ratio of propylene glycol to nitric acid to hydrofluoric acid is about 30:20:1.

19. The composition according to claim 1, wherein said substance etched is a doped amorphous, doped pseudocrystalline or doped polycrystalline silicon.

20. The composition according to claim 1, wherein said substance is doped germanium.

21. The composition according to claim 1, wherein said substance is gallium arsenide.

22. A composition for selectively etching doped silicon, said composition consisting essentially of:

a non-aqueous composition of an alcohol and at least two inorganic acids.

23. The composition according to claim 22, wherein said alcohol is a polyhydric alcohol.

24. The composition according to claim 23, wherein said polyhydric alcohol is selected from the group consisting of ethylene glycol, propylene glycol, butylene glycol, dipropylene glycol, sorbitol, hexylene glycol, 1,3-dibutylene glycol, 1,2,6,-hexanetriol and 1,5-pentanediol.

25. The composition according to claim 23, wherein said polyhydric alcohol is selected from the group consisting of ethylene glycol, propylene glycol.

26. The composition according to claim 22, wherein said alcohol is propylene glycol.

27. The composition according to claim 22, wherein said alcohol is a C<sub>2</sub>-C<sub>6</sub> alcohol.

28. The composition according to claim 27, wherein said C<sub>2</sub>-C<sub>6</sub> alcohol is selected from the group consisting of ethanol, propanol, isopropanol, iso-butanol and n-butanol.

29. The composition according to claim 28, wherein said alcohol is isopropanol.

30. The composition according to claim 22, wherein said inorganic acids are selected from the group consisting of hydrofluoric acid, nitric acid, phosphoric acid, sulfuric acid, boric acid, carbonic acid, perchloric acid and sulfurous acid.

31. The composition according to claim 22, wherein said first inorganic acids is nitric acid and said second inorganic acid is hydrofluoric acid.

32. The composition according to claim 31, wherein said alcohol is propylene glycol.

33. The composition according to claim 22, wherein the ratio of alcohol to a first acid to a second acid is from about 10-50:5-40:1.

34. The composition according to claim 33, wherein the ratio of alcohol to said first acid to said second acid is from about 20-40:10-30:1.

5 35. The composition according to claim 34, wherein the ratio of alcohol to said first acid to said second acid is about 30:20:1.

36. The composition according to claim 32, wherein the ratio of propylene glycol to nitric acid to hydrofluoric acid is from about 10-50:5-40:1.

37. The composition according to claim 32, wherein the ratio of propylene glycol to nitric acid to hydrofluoric acid is from about 20-40:10-30:1.

38. The composition according to claim 32, wherein the ratio of propylene glycol to nitric acid to hydrofluoric acid is about 30:20:1.

39. A composition for etching doped polysilicon from a silicon substrate with high selectivity to undoped polysilicon consisting essentially of:

15 a non-aqueous composition comprising propylene glycol, nitric acid and hydrofluoric acid in a ratio of propylene glycol to nitric acid to hydrofluoric acid is from about 10-50:5-40:1.

40. The composition according to claim 39, wherein the ratio of propylene glycol to nitric acid to hydrofluoric acid is from about 20-40:10-30:1.

41. The composition according to claim 39, wherein the ratio of propylene glycol to nitric acid to hydrofluoric acid is about 30:20:1.

42. A method for selectively etching a doped material comprising:

contacting said doped material with a composition comprising an alcohol and at least two inorganic acids.

43. The method according to claim 42, wherein said alcohol is a polyhydric alcohol.

44. The method according to claim 43, wherein said polyhydric alcohol is selected from the group consisting of ethylene glycol, propylene glycol, butylene glycol, dipropylene glycol, sorbitol, hexylene glycol, 1,3-dibutylene glycol, 1,2,6,-hexanetriol and 1,5-pentanediol.

45. The method according to claim 44, wherein said polyhydric alcohol is selected from the group consisting of ethylene glycol, propylene glycol.

46. The method according to claim 42, wherein said alcohol is propylene glycol.

47. The method according to claim 42, wherein said alcohol is a C<sub>2</sub>-C<sub>6</sub> alcohol.

48. The method according to claim 47, wherein said C<sub>2</sub>-C<sub>6</sub> alcohol is selected from the group consisting of ethanol, propanol, isopropanol, iso-butanol and n-butanol.

49. The method according to claim 47, wherein said alcohol is isopropanol.

50. The method according to claim 42, wherein said inorganic acids are selected from the group consisting of hydrofluoric acid, nitric acid, phosphoric acid, sulfuric acid, boric acid, carbonic acid, perchloric acid and sulfurous acid.

51. The method according to claim 42, wherein a first inorganic acid is nitric acid and a second inorganic acid hydrofluoric acid.

52. The method according to claim 51, wherein said alcohol is propylene glycol.

53. The method according to claim 52, wherein said composition is a non-aqueous composition.

54. The method according to claim 42, wherein the ratio of alcohol to a first acid to a second acid is from about 10-50:5-40:1.

55. The method according to claim 54, wherein the ratio of alcohol to said first acid to said second acid is from about 20-40:10-30:1.

56. The method according to claim 55, wherein the ratio of alcohol to said first acid to said second acid is about 30:20:1.

57. The method according to claim 52, wherein the ratio of propylene glycol to nitric acid to hydrofluoric acid is from about 10-50:5-40:1.

58. The method according to claim 52, wherein the ratio of propylene glycol to nitric acid to hydrofluoric acid is from about 20-40:10-30:1.

59. The method according to claim 52, wherein the ratio of propylene glycol to nitric acid to hydrofluoric acid is about 30:20:1.

5 60. The method according to claim 42, wherein said doped material is a monocrystalline material.

61. The method according to claim 42, wherein said doped material is a polycrystalline material.

62. The method according to claim 42, wherein said doped material is an amorphous material.

63. The method according to claim 42, wherein said doped material is doped polysilicon.

64. The method according to claim 42, wherein said doped material is doped germanium.

15 65. The method according to claim 42, wherein said doped material is gallium arsenide.

66. The method according to claim 42, wherein said doped material is BPSG.

67. The method according to claim 42, wherein said doped material is immersed in said composition.

68. The method according to claim 67, wherein said doped material is immersed in said composition at a temperature of from about -10°C to about 70°C.

69. The method according to claim 68, wherein said doped material is immersed in said composition at a temperature of about 35°C.

70. The method according to claim 42, wherein said doped material is sprayed with said composition.

71. The method according to claim 59, wherein said doped material is immersed in said composition.

72. The method according to claim 77, wherein said doped material is immersed in said composition at a temperature of from about -10°C to about 70°C.

73. The method according to claim 71, wherein said doped material is immersed in said composition at a temperature of about 35°C.

74. A method for etching doped polysilicon from a substrate with high selectivity to undoped polysilicon, said method comprising:

contacting said substrate with a non-aqueous composition comprising propylene glycol, nitric acid and hydrofluoric acid.

75. The method according to claim 74, wherein the ratio of propylene glycol to nitric acid to hydrofluoric acid is from about 10-50:5-40:1.

76. The method according to claim 74, wherein the ratio of propylene glycol to nitric acid to hydrofluoric acid is from about 20-40:10-30:1.

5 77. The method according to claim 74, wherein the ratio of propylene glycol to nitric acid to hydrofluoric acid is about 30:20:1.

78. The method according to claim 74, wherein said substrate is immersed in said composition.

79. The method according to claim 78, wherein said substrate is immersed in said composition at a temperature of from about -10°C to about 70°C.

80. The method according to claim 78, wherein said substrate is immersed in said composition at a temperature of about 35°C.

81. The method according to claim 74, wherein said substrate is sprayed with said composition.

## ABSTRACT

The present invention provides an etching composition which includes a polyhydric alcohol in combination with two inorganic acids. Preferably the etching composition of the present invention is a mixture of a glycol, nitric acid and hydrofluoric acid, with propylene glycol being preferred. The etching composition of the present invention achieves a selectivity of greater than 70:1, doped material to undoped material. The present invention provides an etching formulation which has increased selectivity of doped polysilicon to undoped polysilicon and provides an efficient integrated circuit fabrication process without requiring time consuming and costly processing modifications to the etching apparatus or production apparatus.

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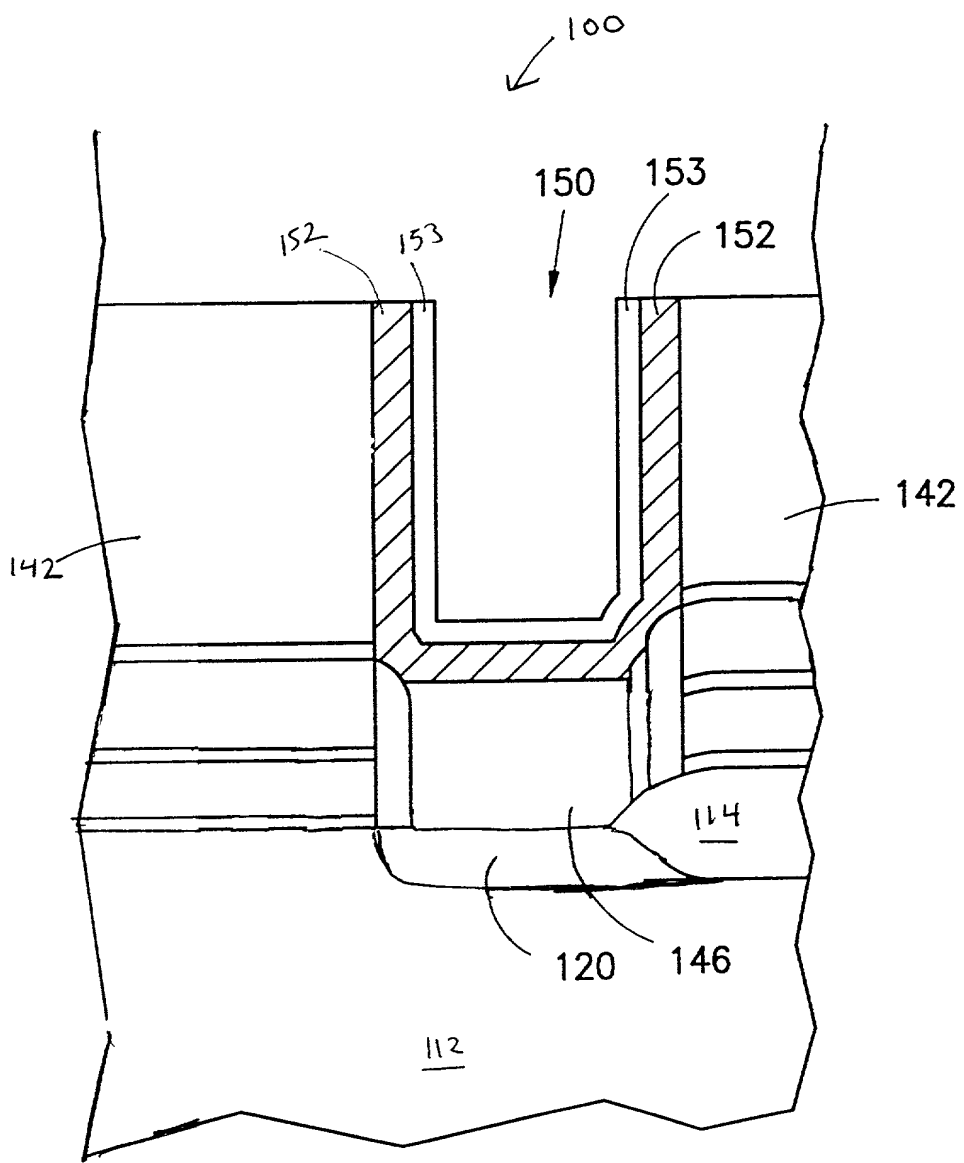


FIG. 1

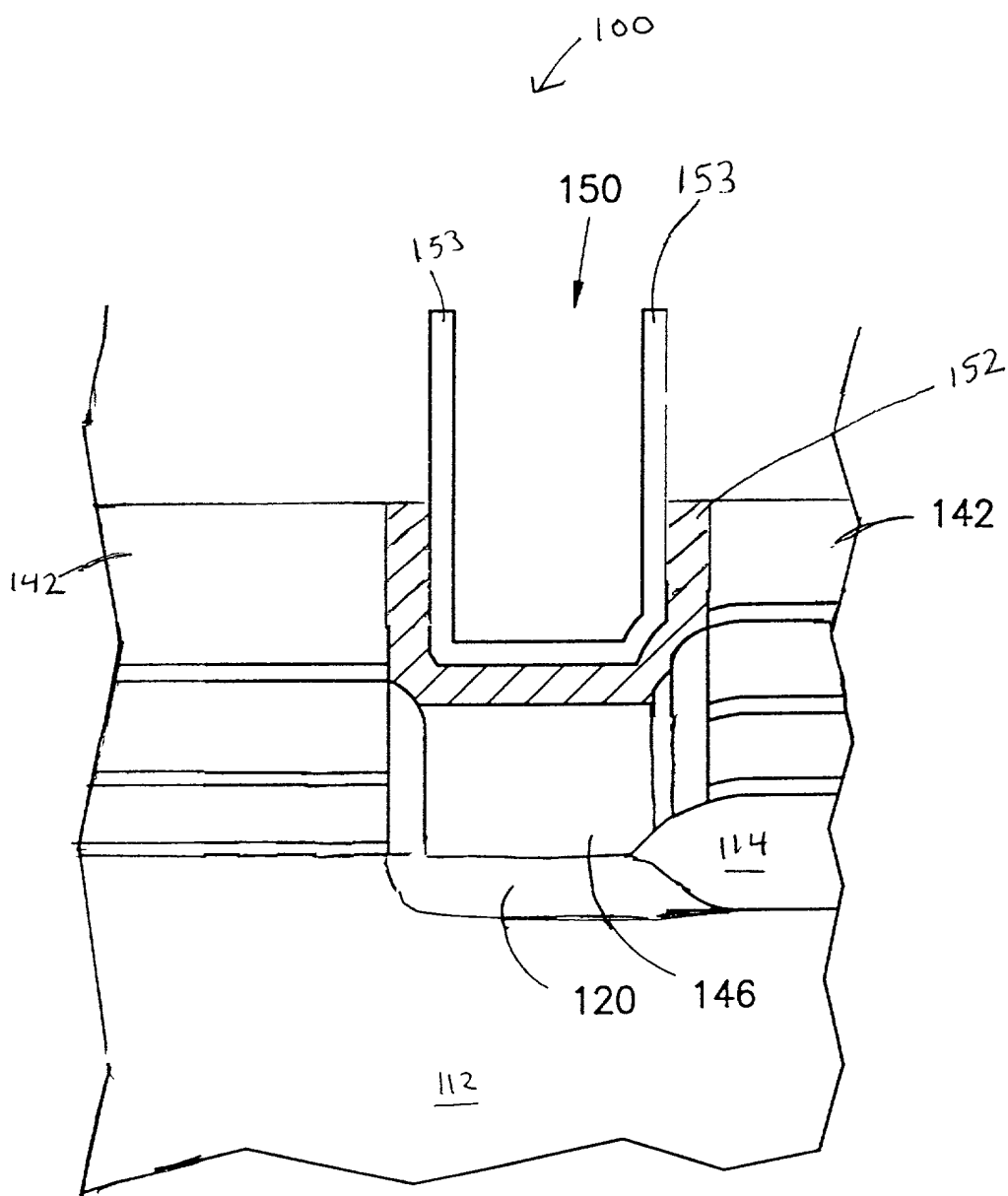


FIG. 2

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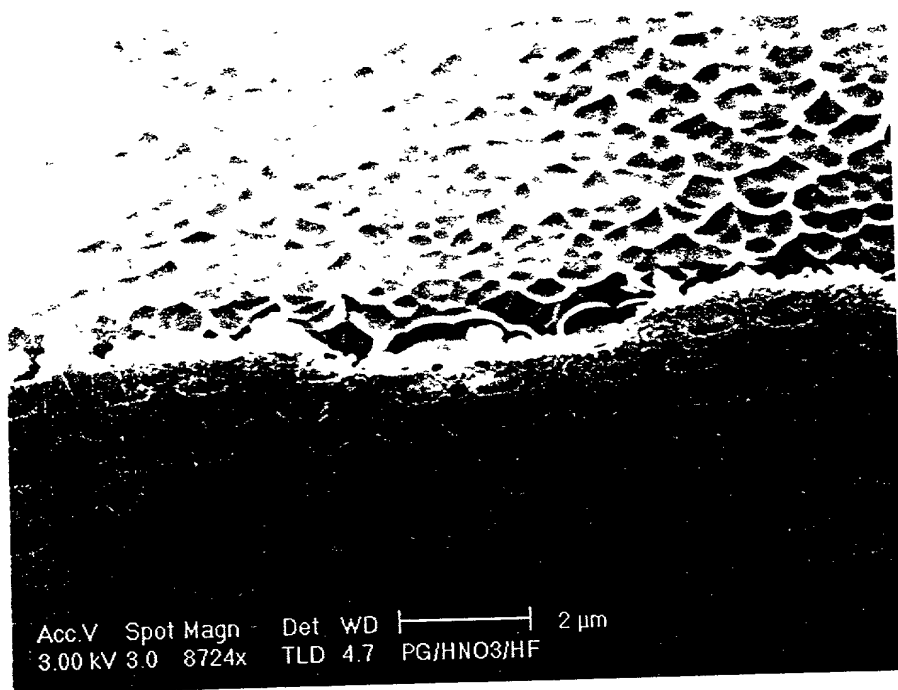


FIG. 3

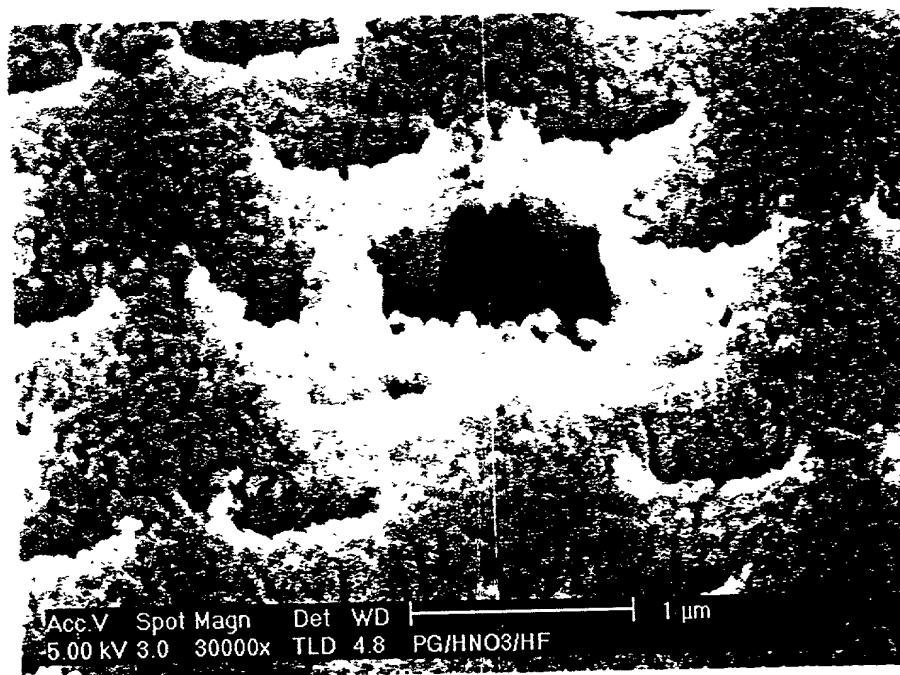


FIG. 4

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

DECLARATION FOR PATENT APPLICATION

As the below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled:

METHOD FOR ETCHING DOPED POLYSILICON WITH HIGH SELECTIVITY TO UNDOPED POLYSILICON.

The specification of which is attached hereto.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by an amendment, if any, specifically referred to in this oath or declaration.

I acknowledge the duty to disclose all information known to me which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119/365 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

None

I hereby claim the benefit under Title 35, United States Code, § 120/365 of any United States and PCT international application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56(a) which became available between the filing date of the prior application and the national or PCT international filing date of this application:

None

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Please address all correspondence to Thomas J. D'Amico of Dickstein Shapiro Morin & Oshinsky LLP located at 2101 L Street, NW, Washington, DC 20037-1526. Telephone calls should be made to Thomas J. D'Amico by dialing (202) 828-2232.

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Inventor's signature  Date 3/31/99

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PATENT

Docket No.: M4065.165/P165

Micron No.: 98-0427.00/US

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Patent Application

Inventors: Garry Mercaldi et al.

Serial No.: Not Yet Assigned

Group Art Unit: Not Yet  
Assigned

Filed: Concurrently Herewith

Examiner: Not Yet Assigned

For: METHOD FOR ETCHING  
DOPED POLYSILICON  
WITH HIGH  
SELECTIVITY TO  
UNDOPED POLYSILICON

POWER OF ATTORNEY BY ASSIGNEE AND

CERTIFICATE BY ASSIGNEE UNDER 37 C.F.R. § 3.73(b)

Micron Technology, Inc., assignee of the entire right,  
title and interest in the above-identified application by virtue  
of the assignment attached hereto (which is also being submitted  
concurrently for recordation), hereby appoints the attorneys and  
agents of the firm of Dickstein Shapiro Morin & Oshinsky LLP  
located at 2101 L Street, NW, Washington, DC 20037-1526, listed  
as follows: Gary M. Hoffman, 26,411; Thomas J. D'Amico, 28,371;  
Donald A. Gregory, 28,954; James W. Brady, Jr., 32,115; Jon D.  
Grossman, 32,699; Mark J. Thronson, 33,082; Laurence D. Fisher,  
37,131; John R. Fuisz, 37,327; James M. Heintz, 41,828; Gianni  
Minutoli, 41,198; Eric Oliver, 35,307; William E. Powell, III,


39,803; James M. Silbermann, 40,413; Richard Veltman, 36,957; June Cohan, 43,741; and Brian Lemm, 43,748, and also attorneys Michael L. Lynch, 30,871; Lia M. Pappas, 34,095; W. Eric Webostad, 35,406; and Charles B. Brantley, II, 38,086 of Micron Technology, Inc. as its attorneys with full power of substitution to prosecute this application and to transact all business in the Patent and Trademark Office in connection therewith.

The assignee certifies that the above-identified assignment has been reviewed and to the best of the assignee's knowledge and belief, title is in the assignee.

Please direct all correspondence regarding this application to the following:

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Dated: Nov 31, 1999